AASHTO

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December 2024 ERRATA for the *Guide for the Development of Bicycle Facilities,* 5th Edition (GBF-5)

December 2024

Dear Customer:

AASHTO has issued an erratum, which includes technical revisions, for the *Guide for the Development of Bicycle Facilities,* 5th Edition (GBF-5). Attached please find the full errata listing of changes.

The changes detailed in the table are displayed in **bold** on the pages within the text. In addition, pages with changes have a gray box in the page header reading as follows:

December 2024 Errata

Please feel free to download additional copies of this listing from the AASHTO online Store at:

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AASHTO staff sincerely apologizes for any inconvenience.

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American Association of State Highway and Transportation Officials

List of Errata for the *Guide for the Development of Bicycle Facilities*, 5th Edition (GBF-5)

Original Page	Section	Existing Text	Corrected Text
xxxix	List of Figures	Figure 5-43: Correction for Skewed Streetcar Crossing—Pavement Markings	Figure 5-43: Railing Designed to Accommodate Bicycle Handlebars
5-66	5.11.4.1	In the first sentence on the page, “(see Figure 5-29)” calls out the wrong figure.	The callout should be “(see Figure 5-28)”.
5-90	Figure 5-43	The figure caption wrongly reads “Figure 5-43: Correction for Skewed Streetcar Crossing—Pavement Markings”.	The figure caption should read “Figure 5-43: Railing Designed to Accommodate Bicycle Handlebars”.
6-21	Table 6-7	The equations are misaligned so “when *S* > *L*…” runs into the line above it.	The equations are aligned so “when *S* > *L*…” is fully visible.
7-9	7.2.4	In the second paragraph, “green-colored pavement or markings (see Section 5.12.12)” calls out the wrong section.	The callout should be “(see Section 5.12.11)”.
7-46	7.9.9	In the paragraph right after the bulleted list, “Section 5.12.12” is the wrong section callout.	The paragraph should call out “Section 5.12.11”.
8-16	Figure 8-11	In the upper right and lower left quadrants of the figure, the text “HERE FOR PEDESTRIANS” spills off the signs.	All figure corrections are made.
		In the lower left quadrant, the “STOP HERE FOR PEDESTRIANS” sign is missing its label, “R1-5c”.	
8-22	8.7.2.2	In the paragraph right after the bulleted list, “the use of green-colored pavement within the bikeway (Section 5.12.12” calls out the wrong section.	The callout should be “(Section 5.12.11)”.
12-10	12.4.3.4	In the first paragraph, the section callout “see Section 9.13)” is incorrect.	The callout should be “(see Section 9.12)”.

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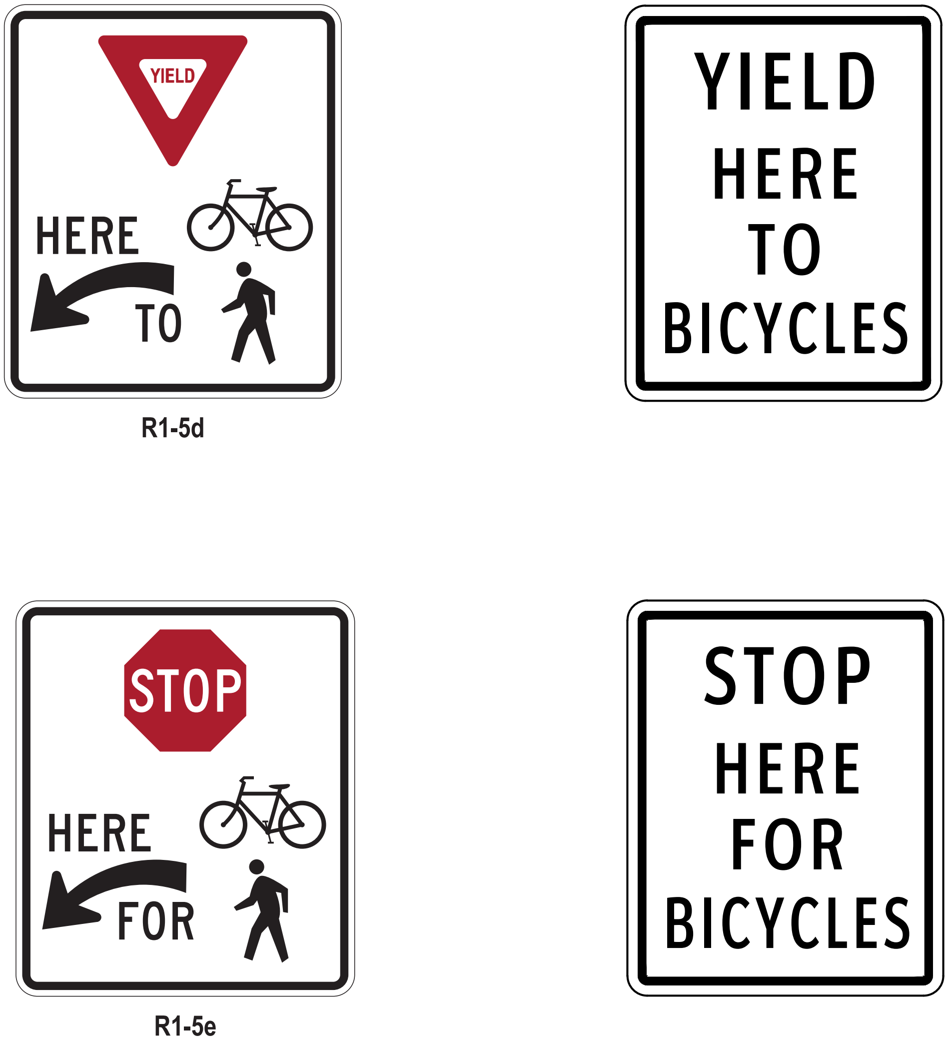


Figure 5-27: Yield Here to (or Stop Here for) Bicyclists Signs

5.11.4. In-Street and Overhead Crossing STATE LAW Signs

5.11.4.1 In-Street Crossing

In jurisdictions where state law provides bicyclists the rights and responsibilities of pedestrians, the placement of an R1-6 series sign can be used to provide notice to motorists of their responsibility to yield to pedestrians and bicyclists within an uncontrolled crosswalk. The R1-6d or R1-6e sign should be used where pedestrians and bicyclists are present in the same crossing location and bicyclists are provided the same rights and responsibilities as pedestrians. Where bicyclists do not have the same rights and responsibilities as pedestrians, the R1-6 or R1-6a sign should be used.

When used on streets operating at or below 30 mph, the In-Street Pedestrian crossing sign (R1-6 series) can achieve motorist yielding rates between 60 and 90 percent. These signs tend to require more frequent maintenance due to their in-street placement.

The R1-6 sign has also shown to be effective when deployed in a "gateway" configuration on multilane streets (see **Figure 5-28**) . This configuration places a sign on the centerline with additional signs located on each approach travel lane line (or gutter if an edge line is not present). (See Chapter 5 References: Western Michigan University, 2016.) This configuration requires experimental approval from FHWA.

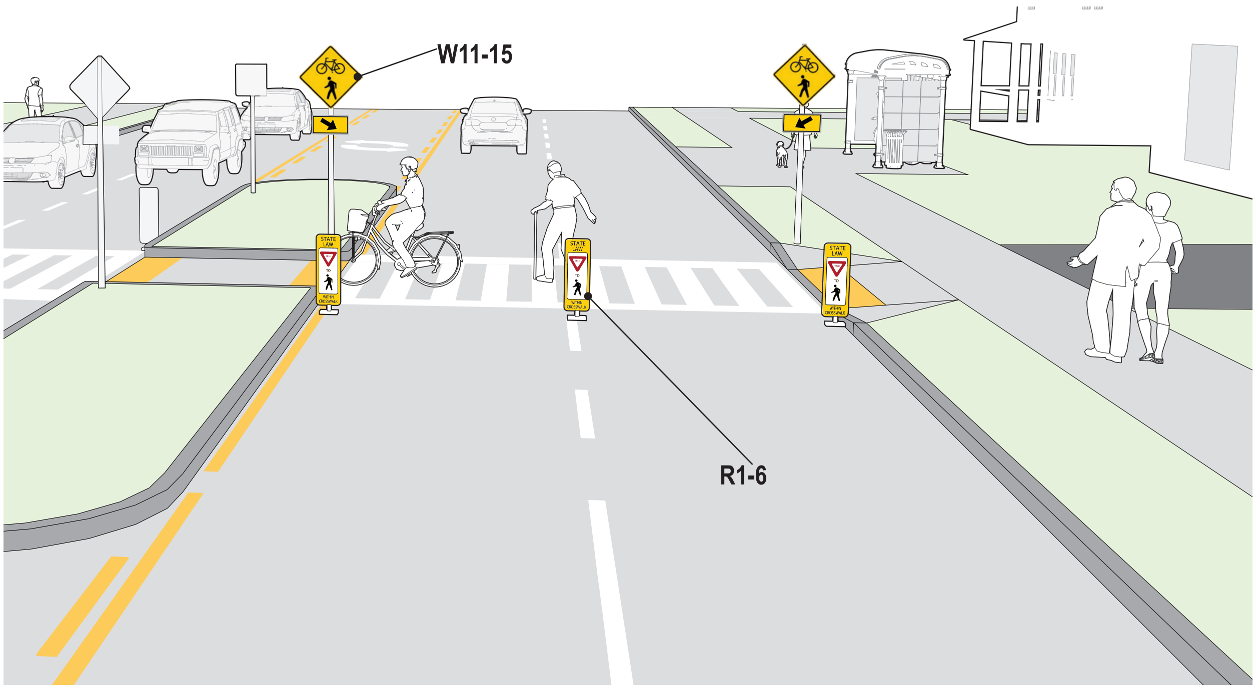


Figure 5-28: In-Street Crossing Signs

5.11.4.2 Overhead Street Crossing

At locations where sight distance might be compromised due to terrain or roadside visual clutter, the crossing can be enhanced with an Overhead Pedestrian Crossing sign (R1-9 series). An R1-9 sign may be upgraded to an active beacon if supplemented with a flashing yellow light. Where pedestrians and bicyclists are present in the same crossing location, the R1-9d or R1-9e sign should be used. Where bicyclists do not have the same rights and responsibilities as pedestrians, the R1-9 or RT1-9a sign should be used.

5.11.5. Turning Vehicles Yield to Pedestrians/Bicyclists Signs

In jurisdictions where state law provides bicyclists the rights and responsibilities of pedestrians, the placement of an R10-15 series sign can be used to provide notice to motorists of their responsibility to yield to pedestrians and bicyclists within a signalized or unsignalized crosswalk.

Where turning vehicles interface with bikeways at signalized intersections, a TURNING VEHICLES YIELD TO (or STOP FOR) BICYCLISTS sign in black letters on a regulatory sign panel may be installed to alert motorists of their requirement to yield or stop for pedestrians or bicyclists within a crossing (see Figure 5-29). In cases where motorists need to be alerted to a potential conflict with pedestrians and bicyclists, the sign should include both the words PEDESTRIANS and BICYCLISTS.

The sign can be located at the near or far side of the intersection. Engineering judgment should be used to determine a location that is conspicuous to the turning motorist.

5.14. Other Design Features

5.14.1. Barriers, Railings, and Fences

Barriers, railings, and fences may be used to protect bicyclists or path users from hazards or to discourage users from venturing onto a bikeway, roadway, transit island, neighboring property, or other areas along a facility that could pose a hazard to the user. These systems typically consist of concrete barriers, fences, railings, hedges, or other linear vegetation.

Barriers, railings, or fences adjacent to bikeways should be a minimum of 42 in. high where bicyclists are operating near those treatments. If the bikeway is sufficiently wide so that a bicyclist does not operate near the barrier, railing, or fence, lower rail heights are acceptable. Where bicycle speeds are likely to be high (such as on a downgrade), where high winds are typical (such as on bridges), or where a bicyclist could impact a railing at a 25 degree angle or greater (such as on a curve), a taller continuous vertical element up to 54 in. may be considered. Some jurisdictions suggest or require taller heights. The designer should confirm local requirements specific to each project. Shy distances between bikeways and all railings, barriers, and fences should be provided as discussed in Section 2.5.3.2.

A typical design for railings includes two to four horizontal elements with vertical elements spaced widely yet frequently enough to provide the needed structural support. Where there is a high vertical drop or a body of water adjacent to the bicycle facility where a railing is provided, engineering judgment should be used to determine whether a railing with smaller openings suitable for bridges should be provided. For bridge railings, openings between horizontal or vertical members should be small enough that a 6-in. sphere cannot pass through them in the lower 27 in. For the portion of railing that is higher than 27 in., openings may be spaced such that an 8-in. sphere cannot pass through them. In remote areas where shared use path volumes are low and a bridge is less than 30 in. above grade, a toeboard with a height of at least 3.5 in. may be considered to define the edge of the path in lieu of providing a railing. Drainage clearance under the toeboard should be considered.

Barriers or railing should begin prior to, and extend beyond, the area of need. Barrier or railing ends that are within the minimum shy distances should be marked with object markers.

Where a bicyclist's handlebar may come into contact with a railing, a smooth, wide rub-rail may be installed at a height of between 36 in. and 44 in. to reduce the likelihood that a bicyclist's handlebar will be caught by the railing (see Figure 5-43). However, on a shared use path with a running grade of five percent or greater, pedestrian accessibility guidelines may require that a handrail be installed at or near this same height. In these cases, the designer should exercise judgement to ensure that any rub-rail that is installed does not interfere with the use of the accessible handrail. If handrails are intended to be pedestrian accessible, the shy distance should be measured from the face of the handrail.

Other materials in addition to railings can be used to separate bikeways from adjacent areas, either due to hazards or to discourage users from venturing onto adjacent properties. Berms or vegetation, or both can serve this function.

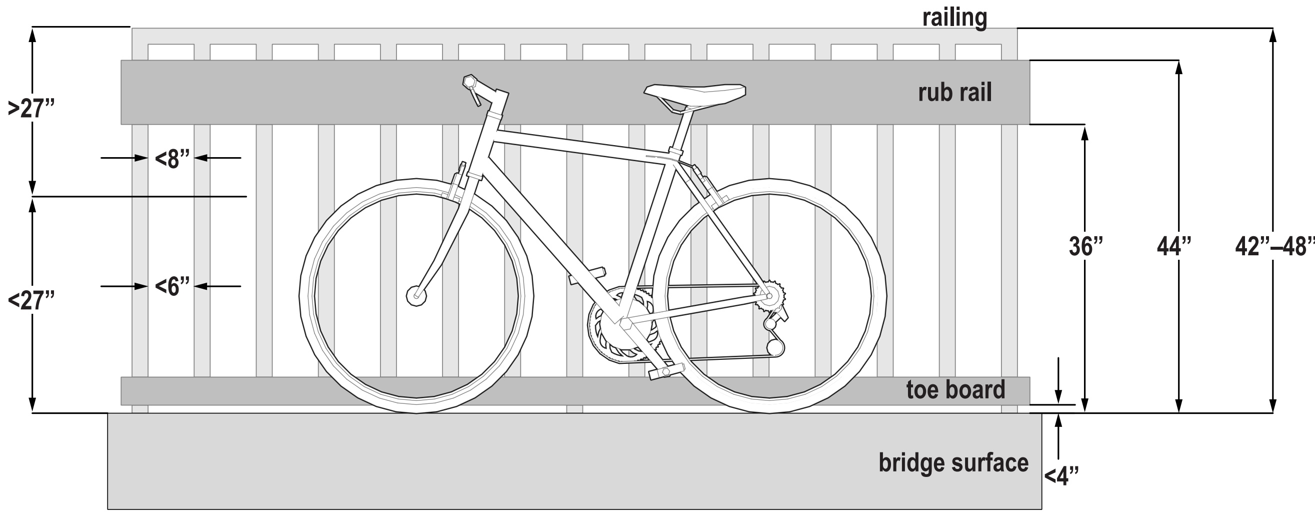


Figure 5-43: **Railing Designed to Accommodate Bicycle Handlebars**

It is not desirable to place a bikeway in a narrow corridor between two fences for long distances, as this creates personal security issues, prevents users who need help from being seen, prevents users from leaving the bikeway in an emergency, and impedes emergency response. If this condition is unavoidable, emergency exits and access to emergency call boxes should be considered.

Depending on the bridge geometry, and environmental factors such as noise and airborne debris generated by the roadway, some locations may also benefit from anti-glare or anti-debris screens placed between the bikeway and motor vehicle traffic. This is particularly pertinent for two-way shared use paths where bicycle traffic and vehicular traffic nearest each other are passing on the opposite side from what is normally expected. Anti-glare screens are placed for the benefit of both bicycle and motor vehicle traffic.

For shared use paths on bridges that pass over freight rail tracks, which are typically governed by Federal Railroad Administration requirements, additional anti-throw screens or fences are usually required on the outer edge where the bridge passes directly over active tracks. These screens may also be required where shared use paths are located on bridges that pass above other rail systems, Interstate highways, or other primary roadways. These screens are taller than the railing heights (typically 8 ft or more from the bikeway surface), and have additional requirements for pass-through spaces, including their provision on both sides of shared use paths located on their own structure. Designers should coordinate with appropriate governing agencies (such as Federal Railroad Administration (FRA), Federal Transit Administration (FTA), local transit agencies) to ensure compliance with regulations specific to each site.

The *Roadside Design Guide* and *AASHTO LRFD Bridge Design Specifications* provide additional guidance for the use of these restraining systems (AASHTO 2011, 2020; see Chapter 5 References).

5.14.2. Lighting

Fixed-source lighting can improve visibility along bicycle facilities at night or under other dark conditions. Lighting can also greatly improve bicyclists' ability to detect surface irregularities under such conditions, even when their bicycles are properly equipped with headlamps. Provision of lighting appropriate for all users should be considered, especially when night-time use is anticipated, such as in the following locations:

- If other designs are not practicable, for shared use paths use a series of switchbacks to traverse the grade. Consider an extra 4 to 6 ft of path width on the approach and at the turn to provide maneuvering space where 180-degree turns are required.
- Provide resting intervals with flatter grades to permit users to stop periodically and rest.
- Consider the provision of accessible pedestrian handrails for pedestrian users (see Section 5.14.1)

Grades steeper than three percent may not be practical for shared use paths with crushed stone or other unpaved surfaces for both bicycle handling and drainage erosion reasons. Typically, grades less than 0.5 percent should be avoided because they are not efficient in conveying surface drainage. Where paths are built in very flat terrain, proposed path grades may be increased to provide a gradually rolling vertical profile that helps convey surface drainage to outlet locations.

See Section 1.6.3 for additional considerations.

6.6.4.2 Vertical Curves

The minimum length of a crest vertical curve is based on the distance needed to provide minimum stopping sight distance for a bicyclist approaching a vertical curve to see a possible obstruction ahead and come to a stop. This condition should presume that an unexpected stop requiring 2.5 seconds of reaction time will be necessary for adult bicyclists. Table 6-8 provides the minimum curve length for crest vertical curves based on stopping sight distance and the algebraic grade difference for the vertical curve. A recumbent bicyclist is recommended as the design user for vertical curves because their eye heights are lower than the typical adult bicyclist, thus limiting sight distance over crest vertical curves. The eye height of the recumbent bicyclist is assumed to be 46 in. (approximately 85th percentile height of recumbent bicyclists), and the object height is assumed to be at the ground surface (for example, 0 in.) to recognize that impediments to bicycle travel can exist at pavement level. The minimum length of a vertical curve can also be calculated using the equation shown in Table 6-7.

Table 6-7: Length of Crest Vertical Curve to Provide Sight Distance Equations

Length of Crest Vertical Curve to Provide Sight Equations

when $S > L$ $$L = 2S - \frac{200(\sqrt{h_1} + \sqrt{h_2})^2}{A}$$

when $S < L$ $$L = \frac{AS^2}{100(\sqrt{2h_1} + \sqrt{2h_2})^2}$$

where:

L	=	minimum length of vertical curve (ft)
A	=	algebraic grade difference (percent)
S	=	stopping sight distance for flat grade (ft)*
h_1	=	eye height (3.83 ft for a typical recumbent bicyclist)
h_2	=	object height (0 ft)

*See Tables 5-2 and 5-3.

Table 6-8: Minimum Length of Crest Vertical Curve Based on Stopping Sight Distance

Minimum Length of Crest Vertical Curve (ft) Based on Stopping Sight Distance														
A	S = Stopping Sight Distance for flat grade (ft)*													
(%)	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2									17	57	97	137	177	217
3						25	65	105	145	185	225	265	307	352
4				9	49	89	129	169	209	253	301	353	409	470
5			7	47	87	127	167	211	261	316	376	441	512	587
6			32	72	112	154	201	254	313	379	451	530	614	705
7		11	51	91	132	179	234	296	366	442	526	618	716	822
8		24	64	104	150	205	267	338	418	505	602	706	819	940
9		35	75	117	169	230	301	381	470	569	677	794	921	1057
10	3	43	84	131	188	256	334	423	522	632	752	883	1023	1175
11	10	50	92	144	207	281	368	465	574	695	827	971	1126	1292
12	16	56	100	157	226	307	401	508	627	758	902	1059	1228	1410
13	21	61	109	170	244	333	434	550	679	821	978	1147	1331	1527
14	25	66	117	183	263	358	468	592	731	885	1053	1236	1433	1645
15	29	70	125	196	282	384	501	634	783	948	1128	1324	1535	1762
16	32	75	134	209	301	409	535	677	836	1011	1203	1412	1638	1880
17	35	80	142	222	320	435	568	719	888	1074	1278	1500	1740	1997
18	37	85	150	235	338	461	602	761	940	1137	1354	1589	1842	2115
19	40	89	159	248	357	486	635	804	992	1201	1429	1677	1945	2232
20	42	94	167	261	376	512	668	846	1044	1264	1504	1765	2047	2350
Shaded area represents S = L. Minimum length of vertical curve = 5 ft														

*See Table 5-2.

6.6.5. Cross Slope and Superelevation

As discussed in Section 5.6.3, cross slopes are limited by pedestrian accessibility guidelines to a maximum of two percent for all pedestrian facilities, which includes shared use paths. A cross slope closer to one or 1.5 percent is generally recommended to be more comfortable for pedestrians while still conveying surface drainage and allowing for construction tolerances to keep the constructed cross slope below two percent. A

In some situations, however, one-way separated bike lanes are not practical or desirable, due to right-of-way constraints or a variety of other reasons. In these locations, the challenges of accommodating a two-way facility on one side of the roadway must be weighed against the constraints posed by one-way facilities to determine the optimum solution.

Providing a two-way separated bike lane or side path on one side of a street introduces a counterflow movement by bicyclists, which can be challenging—but not impossible—to accommodate. This also applies to a counterflow separated bike lane on a one-way street. Care should be given to the design of intersections, driveways, and other conflict points, as people walking and driving may not anticipate bicyclists traveling in the counterflow direction (see Section 2.7). Motorists entering or crossing the roadway often will not notice bicyclists approaching from their right and motorists turning from the roadway across the bikeway may likewise fail to notice bicyclists traveling the opposite direction from the norm.

Strategies should be employed to manage or eliminate conflicts between counterflow bicyclists and motorists, who are primarily focused on identifying gaps in oncoming traffic and may be less cognizant of bicyclists approaching the intersection. Where appropriate, signal phasing should be used to eliminate conflicts between turning motorists and bicyclists traveling in the counterflow direction. Geometric treatments to slow turning motorists prior to the conflict point (such as raised crossings or hardened center lines) should be considered (see Section 5.10.1). In addition to providing the sight distance identified in Section 5.5, traffic control or warning signs, and high-visibility bicycle crossing or crosswalk pavement markings, should be installed to alert motorists to the presence of counterflow bicyclists. Signs warning counterflow bicyclists (and pedestrians) to WATCH FOR TURNING VEHICLES may also be appropriate at intersections approaches to warn users of the potential conflict.

At the terminus of the bikeway, the counterflow bicyclist must be clearly directed back into the traffic mix in the correct direction of travel. This often requires the design of queuing spaces for bicyclists to wait outside the path of other bicyclists, motorists, and pedestrians while they wait to turn or transition from the bikeway.

Design solutions to mitigate these conflicts are addressed in Section 7.9.

7.2.4. Determining Where to Locate the Separated Bike Lane

Choosing where to locate separated bike lanes within the roadway is typically a balance between enhancing connectivity and avoiding conflicts. As discussed in Section 2.7, it is generally preferable to locate bikeways on the right side of one-way streets. This is true for both one-way and two-way separated bike lanes.

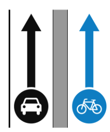
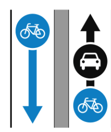
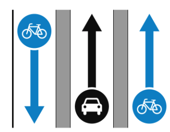
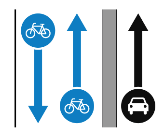
On one-way streets and on two-way streets with medians, it is sometimes appropriate to consider placing the separated bike lane on the left side of the street where that placement can reduce potential conflicts compared to a right side placement. A comparison of potential conflicts resulting from motor vehicle turning movements, parking turnover, loading activities, or transit service can inform the decision. Separated bike lanes on the left side of a street can be unexpected to motorists where right side placement is typical, which can increase crash risks in the short term (see Section 2.7). In those situations, it may be necessary to install additional traffic control measures to increase motorist awareness of the bicycle crossing at intersections and driveways by providing marked crossings (see Section 5.12.7), green-colored pavement or markings (see **Section 5.12.11**), or warning or regulatory signs (see Section 5.11).

It may be beneficial to locate the separated bike lane on one side of the street to better connect to the bicycle network or provide access to destinations such as businesses, schools, transit centers, employment centers, parks, and neighborhoods. It may also be beneficial to locate one-way or two-way separated bike lanes on both sides of the street to provide bicyclists with full access to destinations along both sides of the street.

Tables 7-1 and 7-2 provide overviews of configurations for typical one-way and two-way roadways with separated bike lanes and discussion of associated issues.

There are some examples of two-way bikeways or side paths that have been placed in the center median of a street or roadway. These are unique facilities that are typically provided where conflicts along the street edge cannot be mitigated, and fewer conflicts exist in the center median. Ease of access to the median bikeway, as well as the design of intersection movements, are key considerations for this type of facility.

Table 7-1: Separated Bike Lane Configurations on a One-Way Street

Corridor-level Planning Considerations	One-way SBL	Counterflow SBL	One-way SBL Plus Counterflow SBL	Two-way SBL
				
Access to Destinations	Limited access to other side of street		Full access to both sides of street	Limited access to other side of street
Network Connectivity	Does not address demand for counterflow bicycling; may result in wrong way riding or sidewalk riding	Requires bicyclists traveling in the direction of traffic to share the lane (may result in wrong way riding or sidewalk riding); counterflow progression through signals may be less efficient	Accommodates two-way bicycle travel, but counterflow progression through signals may be less efficient	
Crash Risk	Lower because pedestrians and turning drivers expect concurrent bicycle traffic	Higher because pedestrians and turning drivers may not expect counterflow bicycle traffic		
Intersection Operations	May use existing signal phases; bike phase may be required depending on volumes	Typically requires additional signal equipment; bike phase may be required depending on volumes		

Note: All characterizations are relative to other options in the table, not other facility types.

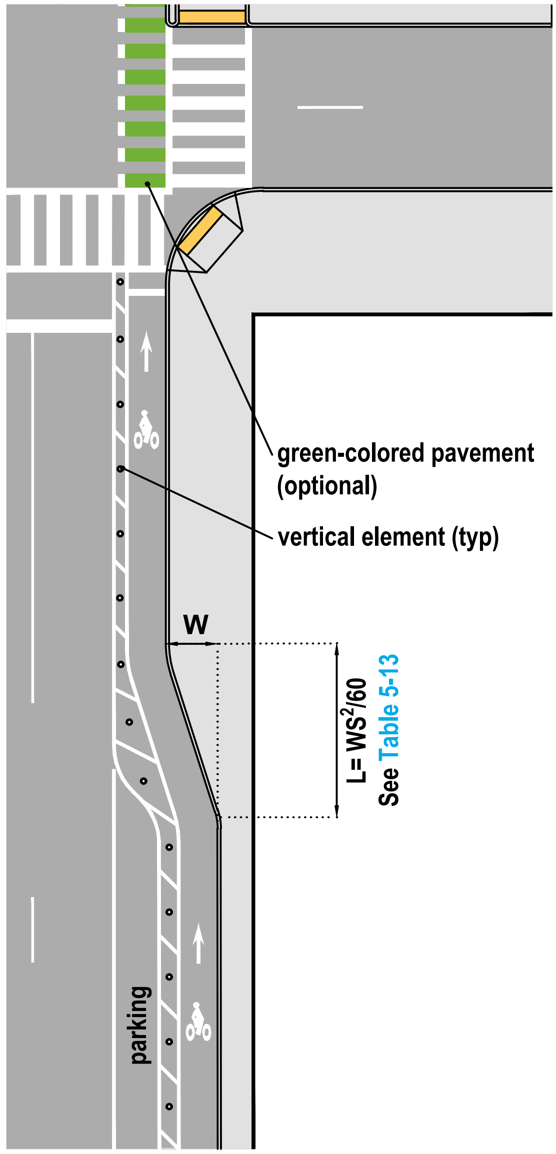


Figure 7-19: Bend-In Example with Existing Diagonal Curb Ramp

If these strategies do not achieve the desired results, it may be necessary to transition the separated bike lane to a regular bike lane at the intersection, to design the intersection with a mixing zone (see Section 7.9.9), or phase-separate the bicyclist and motorist movements (see Chapter 10).

7.9.9. Intersection Design with Mixing Zones

Mixing zones create a defined merge point for a motorist to yield and cross paths with a bicyclist in advance of an intersection. They require removal of the physical separation between the separated bike lane and the motor vehicle travel lane. This allows motorists and bicyclists to cross paths within a travel lane where either bicyclists reach a conventional bike lane near the stop bar (see Figure 7-20), or motorists and bicyclists share a motor vehicle lane (see Figure 7-21). For both situations, a clearly-defined, slow-speed merging area is preferred to increase the predictability and safety of all users.

Protected intersections are preferable to mixing zones and a conventional bike lane approaching an intersection is preferable to a bicyclist sharing a motor vehicle lane. Mixing zones are generally appropriate as an interim or retrofit solution, or in situations where right-of-way constraints make it infeasible to provide a protected intersection.

Mixing zones are only appropriate on street segments with one-way separated bike lanes. They are not appropriate for two-way separated bike lanes or side paths due to the counterflow bicycle movement.

The speed of motor vehicles at the merge point is a critical factor for the safety and comfort of bicyclists in mixing zones to accommodate the interested but concerned design user profile. The following strategies can be used to reduce speeds of motor vehicles entering the merge point to 20 mph or less:

- Minimize the length of the merge area by designing the entry merging area to achieve a target operating speed of 20 mph.
- Locate the merge point as close as practical to the intersection.
- Minimize the length of the storage portion of the turn lane based on anticipated vehicle queue length.
- Provide a buffer and physical separation (such as flexible delineator posts) from the adjacent through lane after the merge area, if feasible.
- Highlight the conflict area with green-colored pavement and dotted bike lane markings (see Figure 7-20), as necessary, or shared lane markings (see Figure 7-21).
- Raise the elevation of the turn lane at the start of the mixing zone.

Green-backed shared lane markings may further highlight the shared lane environment, but their use requires FHWA experimental approval (see Figure 7-21 and **Section 5.12.11**).

A BEGIN RIGHT (or LEFT) TURN LANE YIELD TO BIKES sign (R4-4) should be provided at the beginning of the merge area. Parking should be restricted in advance of the merge area in accordance with sight distance guidance in Section 5.5. As discussed in Section 7.9.5, adequate sight distance is needed between bicyclists and motorists at conflicts, including at mixing zones. As shown in Figure 7-20, the provision of a 50-ft minimum clear space and a lateral shift of the bike lane approaching the mixing zone can help to bring bicyclists into a more visible position.

In locations where a bicyclist may desire to turn left at the intersection instead of proceeding straight, a two-stage bicycle turn box may be provided on the cross street (see Figure 7-38).

Where posted speeds are 35 mph or higher, or in locations where it is necessary to provide storage for queued vehicles, it may be necessary to provide a deceleration/storage lane to allow motorists to slow to speeds of 20 mph or lower prior to the merge point where they cross paths with bicyclists. If a deceleration lane is required, the bikeway may need to transition to a conventional bike lane. Figure 7-20, Option 2 of Figure 9-23, and Figure 9-25 provide examples of this transition. Bicycle ramps that transition to shared use paths may be appropriate to accommodate the interested but concerned design user profile (see Section 11.4) in locations where a separated bike lane is discontinued. See Section 9.12.3 for further discussion.

In locations where large vehicles will frequently use the right-turn lane, designers may consider not providing vertical elements (such as flexible delineator posts) in the buffer between the through lane and mixing zone. At locations with high volumes of large vehicles, designers may consider extending the separated bike lane to the intersection and providing a protected bike phase that phase-separates the through bicyclists from turning motorists. See Section 10.3 for additional considerations.

8.5.2. Major Street Medians

Raised medians can be constructed to restrict through motor vehicle access while allowing through bicyclist and pedestrian access.

8.5.2.1 Median Crossing Purpose

A key consideration in the median design is whether it is desired to provide pedestrian and bicyclist a two-stage or single-stage crossing.

When used at uncontrolled crossings of major streets or roads with multiple travel lanes in each direction, a refuge median is desirable to allow a two-stage crossing following the guidance of Section 5.10.1.1. These uncontrolled crossings should also be evaluated to confirm whether other treatments may be necessary (see Section 5.9), including the provision of active traffic control devices such as rapid flashing beacons or traffic signals (see Chapter 10) to facilitate the crossing.

At locations where bicyclists can cross the roadway in a single stage or where there are traffic signals, the primary purpose of the median is to restrict through traffic. In these locations the median may be as narrow as 2 ft, or a hardened centerline can be installed to prevent through motorist traffic following the guidance of Section 5.10.1.2.

In all locations, the medians should extend outside the limits of the intersection to prevent motorists from bypassing them.

8.5.2.2 Median Opening Size

When medians or hardened centerlines are used to restrict through motorist access by extending completely across an intersection, the median opening must be carefully designed to discourage motorists from attempting to enter the bicycle crossing while allowing bicyclists to pass through, especially in situations where the median opening is located in the line of travel for a motorist. This can be accomplished by providing separate median openings for each direction of bicycle travel and limiting the opening to a width between 5 and 6.5 ft, which is narrower than the median design guidance of Section 5.10.1.

Where a bicycle opening wider than 6.5 ft is desired to accommodate two-way bicycle operation, to serve high volumes of bicyclists, or to provides for shared space with pedestrians, it may be necessary to consider the use of vertical elements (such as flexible delineator posts) to restrict motorists. Care should be taken to maintain the recommended 5 ft and 6.5 ft width between vertical elements.

Median openings can be designed to allow emergency vehicles to cross them, while discouraging motorists from crossing them by following the guidance for restricting vehicles onto shared use paths at intersections (see Section 6.7.8).

All treatments intended for pedestrian access should provide an accessible pedestrian route.

8.5.3. Diagonal Diverter

Diagonal diverters prevent through motor vehicle movements in all directions at street intersections, requiring motorists to turn left or right. These are typically installed at four-way intersections of local streets. Diagonal diverters require a physical barrier to restrict motor vehicle access and force motorists to turn off of the bicycle boulevard. Diagonal diverters may be constructed with curb extensions with or without drainage channels at the curb, bollards, or a guardrail.

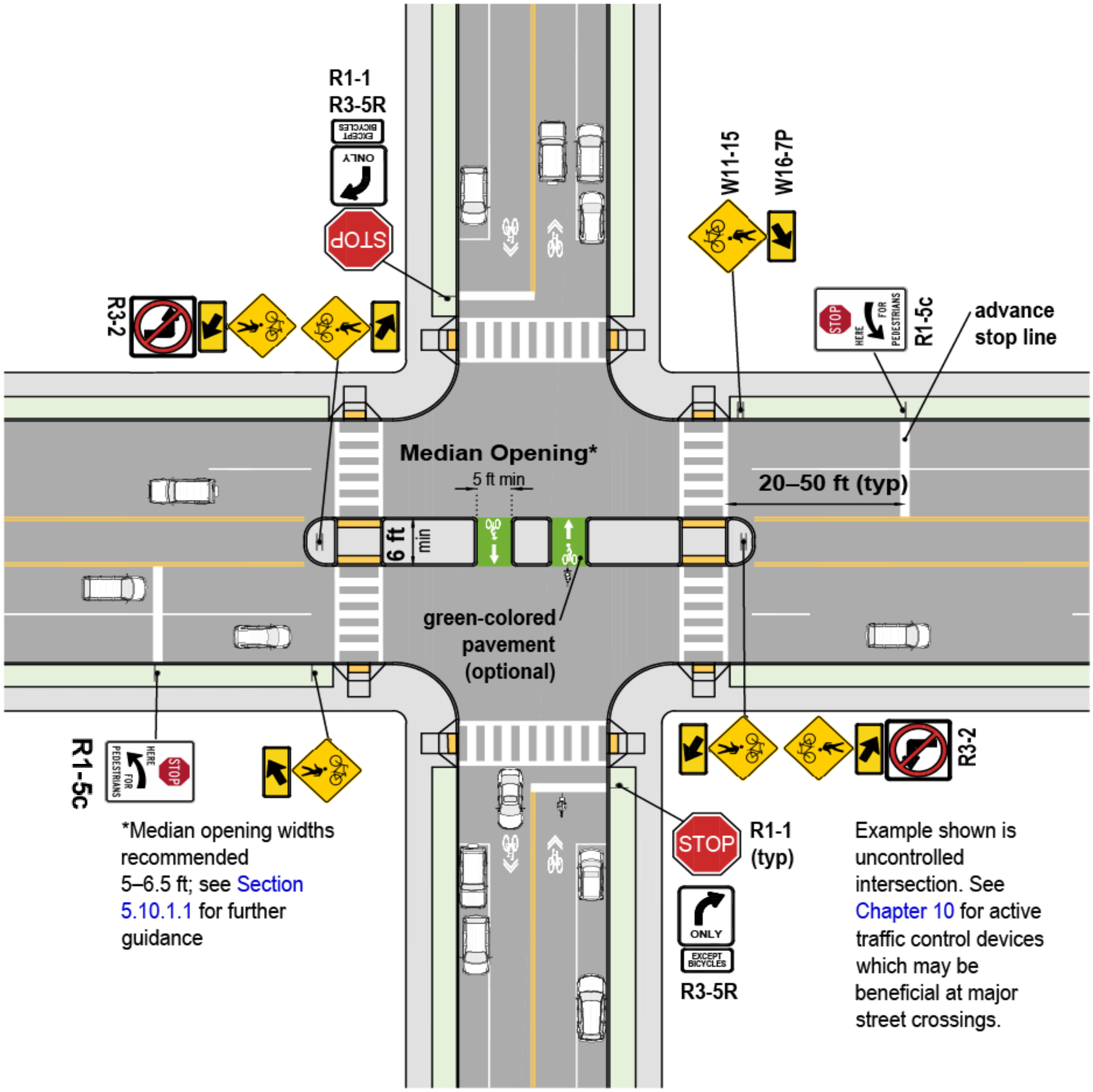


Figure 8-11: Example of a Median Used to Divert Traffic at a Major Street Crossing

Like a median or hardened centerline used for traffic diversion, the diagonal diverter must allow bicyclists to pass through. This can be accomplished by providing a median opening between 5 and 6.5 ft in width for each direction of bicycle travel. Although a bicyclist refuge space is desirable within the median, the refuge space is not required because of the lower volume and lower speed, local street context. A separate pedestrian-accessible route should be provided.

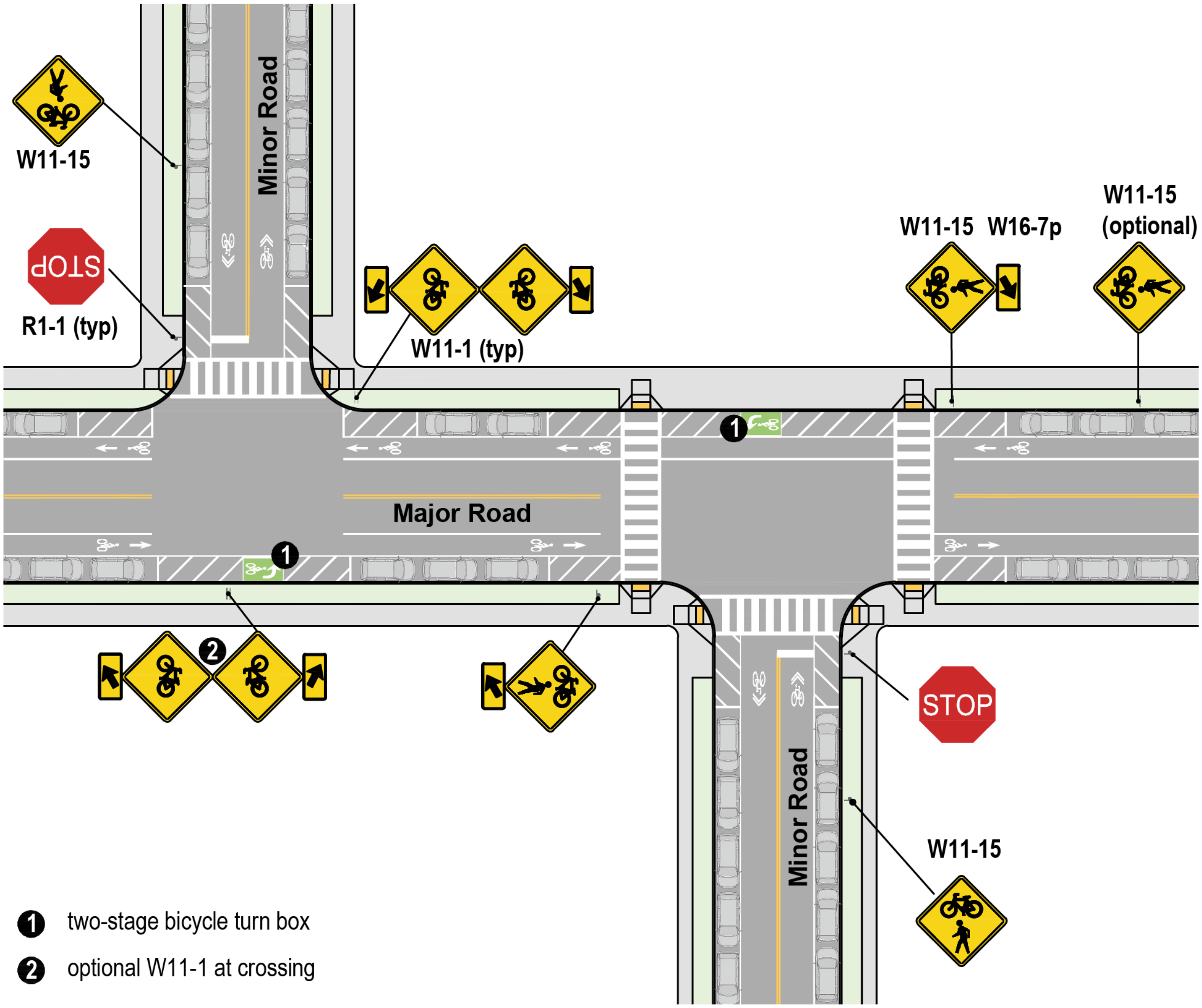


Figure 8-14: Example of Connecting Offset Bicycle Boulevard Segments Using Bike Lanes and Two-Stage Bicycle Turn Boxes

two-way separated bike lane be considered. Where a two-way separated bicycle lane or side path is provided, the street buffer between the street and bikeway should be made as wide as practical to:

- Improve comfort for bicyclists operating counter-flow to traffic;
- create space for bicyclists queuing, and
- allow the construction of a protected intersection at the terminus of the bikeway.

On-street parking should be eliminated where right-of-way is constrained or where sight lines would be limited with the preservation of parking (see Section 5.5). Consideration should be given to the use of green-colored pavement within the bikeway (see **Section 5.12.11**), and a bike crossing (see Section 5.12.7) should be marked to improve the conspicuity of the bikeway and help bicyclists navigate the facility.

Where an activated beacon, pedestrian hybrid beacon, or traffic signal is required to cross the street, detection may be passive or provided by a curbside push button (see Section 10.6).

Where it is determined that traffic control is necessary at the end of the bikeway entering the minor street, yield control is recommended.

8.7.2.3 Center Left-Turn Lanes

For crossings of lower-volume, two-lane streets, a couplet of center bicycle-only left-turn lanes may be used to facilitate an offset crossing along a bicycle boulevard. Center left-turn lanes are appropriate where there are sufficient gaps between vehicles to allow bicycles to enter the left-turn lane. However, this treatment places bicyclists in the middle of the major street; thus, its use should be limited to locations where major road vehicle speeds are below 35 mph. To improve comfort and safety, it is preferable for the bicycle lane to have a buffer between the bicycle lane and adjacent travel lane.

The presence of a median to protect the left-turn bicycle lanes is preferable to improve comfort and safety of bicyclists in the middle of the street. Motorist left turns onto and from the bicycle boulevard should be restricted.

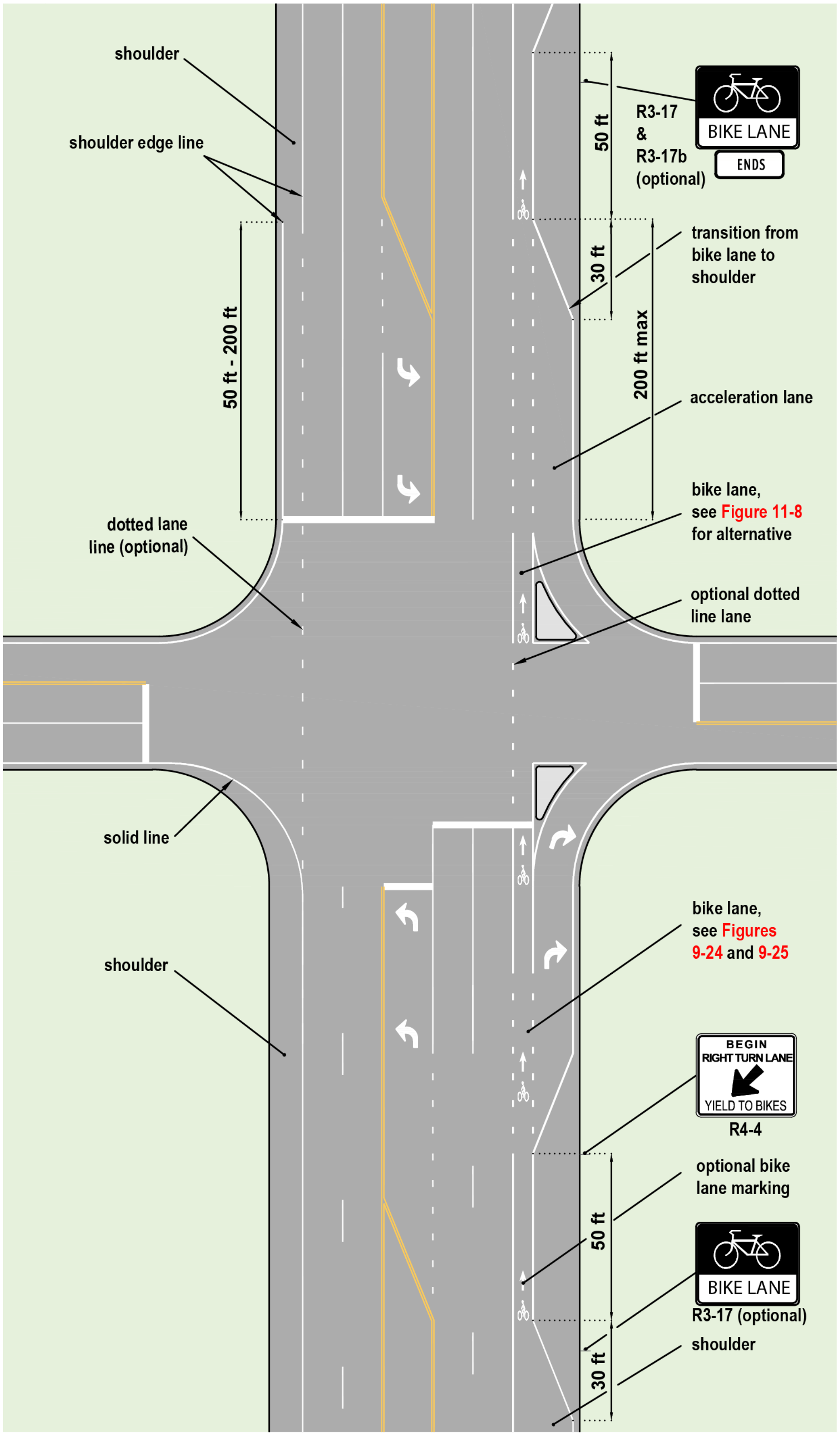


Figure 12-4: Example Shoulder Marking to Accommodate Bicycling at Locations with and without Right-Turn Lanes

At locations where a right-turn lane is provided, paved shoulders may transition to bike lanes or a shared right-turn lane (see **Section 9.12**) on the intersection approach. Where bike lanes are introduced in rural areas with shoulders, it may be appropriate to install BIKE LANE BEGINS and BIKE LANE ENDS signs to clarify the limits of the bike lane and the shoulder where vehicles may use the shoulder for stopping, loading, or parking if vehicles are likely to occupy the bike lane.

Figure 12-5: Shoulder Transition to Bike Lane at a Right-Turn Lane on a Rural Arterial

At locations where there are higher volumes of right-turning traffic and higher volumes of bicyclists, it may be appropriate to transition the shoulder to a separated bike lane or side path (see Chapter 7) prior to the intersection, and then transition back to a paved shoulder after the intersection. This may be desirable at locations near high-speed exit and entrance ramps to highways, or along high-volume, high-speed rural arterials with long deceleration and right-turn lanes where on-street bike lanes are not a preferred treatment (see Chapter 11).

12.4.3.4.1 Shoulder Design with Bypass Lanes

Shoulder bypass lanes are occasionally installed on two-lane roadways at intersections to reduce motorist rear-end collisions where motorists are stopped within the travel lane to turn left. They are created by repurposing portions of a shoulder to allow through moving motorists to bypass the stopped motorist within the shoulder. Where this configuration is used on a highway with paved shoulders, at least 4 ft of useable shoulder pavement clear of rumble strips should be carried through the intersection along the outside of the bypass lane. At locations where guardrails are present, an additional 2 ft of shoulder width is recommended. This shoulder bicycle accommodation is preferable on roadways with high volumes and operating speeds. An example of a preferred bypass lane treatment with a continuous paved shoulder usable by bicyclists is shown in Figure 12-6.